BLOOD FLOW AND PRESSURE CHANGES THAT OCCUR WITH TILT-IN-SPACE

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Background

Pressure Ulcer Development

Possible mechanisms for pathophysiologic responses

1. Ischaemia of soft tissues occurs as a result of the occlusion or collapse of capillaries.
2. A disruption of the equilibrium in the interstitium between cells affects terminal capillaries and lymph vessels.
3. Cell damage results from prolonged deformation.

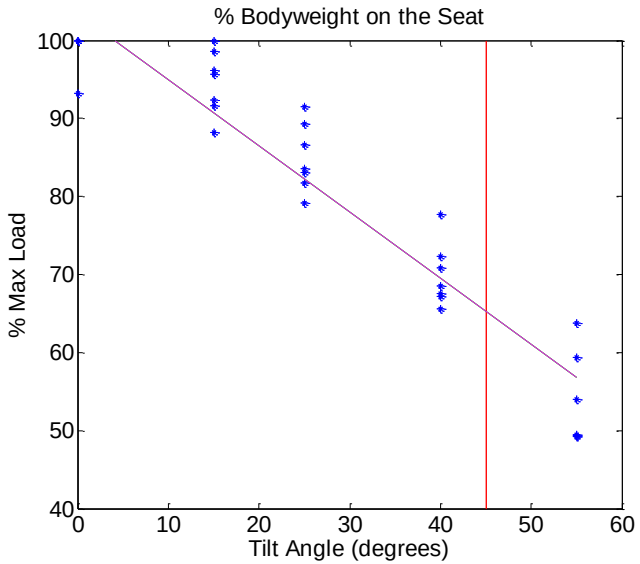
Oomens, C. W., O. F. Bressers, et al. (2003). "Can loaded interface characteristics influence strain distributions in muscle adjacent to bony prominences?" Comput Methods Biomech Biomed Engin **6**(3): 171-80.

Tilt-in-Space for Pressure Relief

- Our local seating clinic prescribed >125 in 2007
- Justification – lack of ability to independently reposition or do weight shifts (pressure ulcer prevention); history of current or previous skin breakdown

Tilt-in-Space for Pressure Relief

- Studies say interface pressure decreases as tilt angle increases.
- Many clinicians teach 45º-55º or "all the way back"
- Literature varies between > 30º and up to 45º
- More appears to be better



Tilt-in-Space for Pressure Relief

- How much pressure reduction at the buttocks with tilt?
- Does blood flow change with tilt?
- How much of a tilt is needed to affect pressure or blood flow?
- Do we have to consider the starting position?
  - Is a 15^{o} tilt from upright the same as a 15^{o} tilt from 15^{o}?

RERC

Aim: To determine the impact of tilting on blood flow and localized tissue loading.

Hypotheses

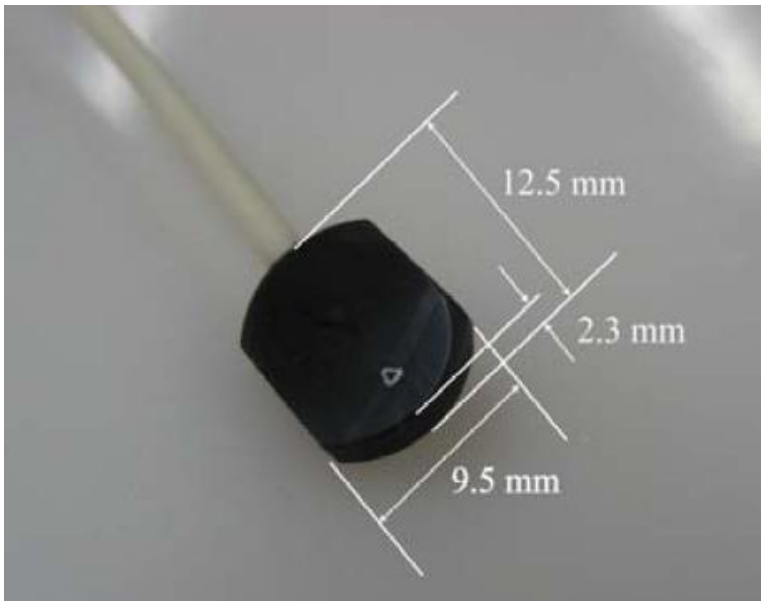
- H1. The minimum tilt position required to increase blood flow is less than 45°.
- H2. There is a significant decrease in loading at the minimum tilt required for increased bloodflow.
- H3. Small changes in tilt angle (15°) when starting in an upright position result in:
  - increased blood flow
  - decreased pressure
- H4. Small changes in tilt angle (15°) when starting in a tilted position (15°) result in:
  - increased blood flow
  - decreased pressure

Participants

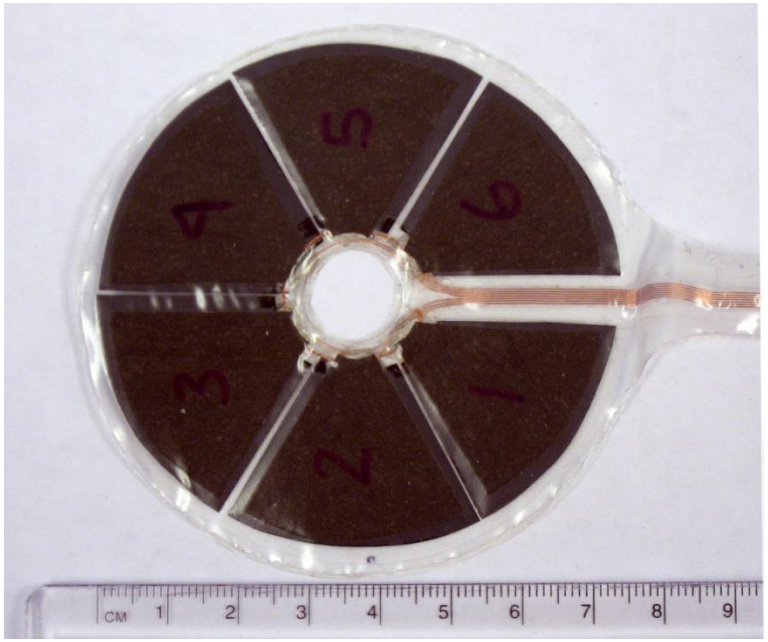
- 11 subjects with SCI
- Gender
  - 9 men
  - 2 women
- Race/Ethnicity
  - 7 African-American
  - 3 Caucasian
  - 1 biracial.
- Years using a wheelchair
  - 9.4 (5.7)
  - Range: 9 months - 18 years

Instrumentation

Laser Doppler Flowmetry Probe

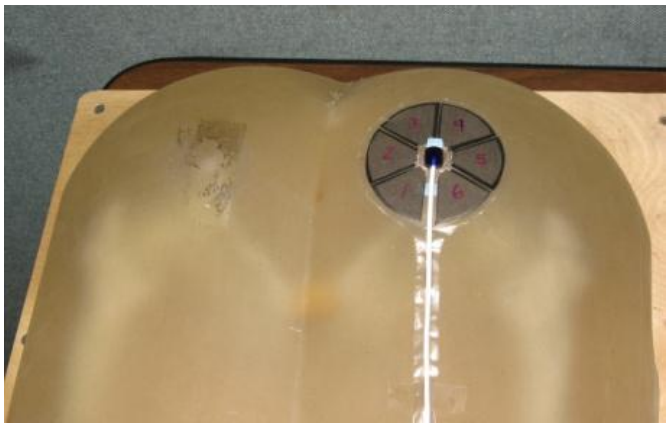


Interface Pressure Sensor



Protocol

- Informed consent
- Attach interface pressure sensor to skin at ischial tuberosity while lifted with net
- Attach Doppler probe in center hole of pressure sensor



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NIDRR
catea
Georgia Tech College of Architecture

Protocol

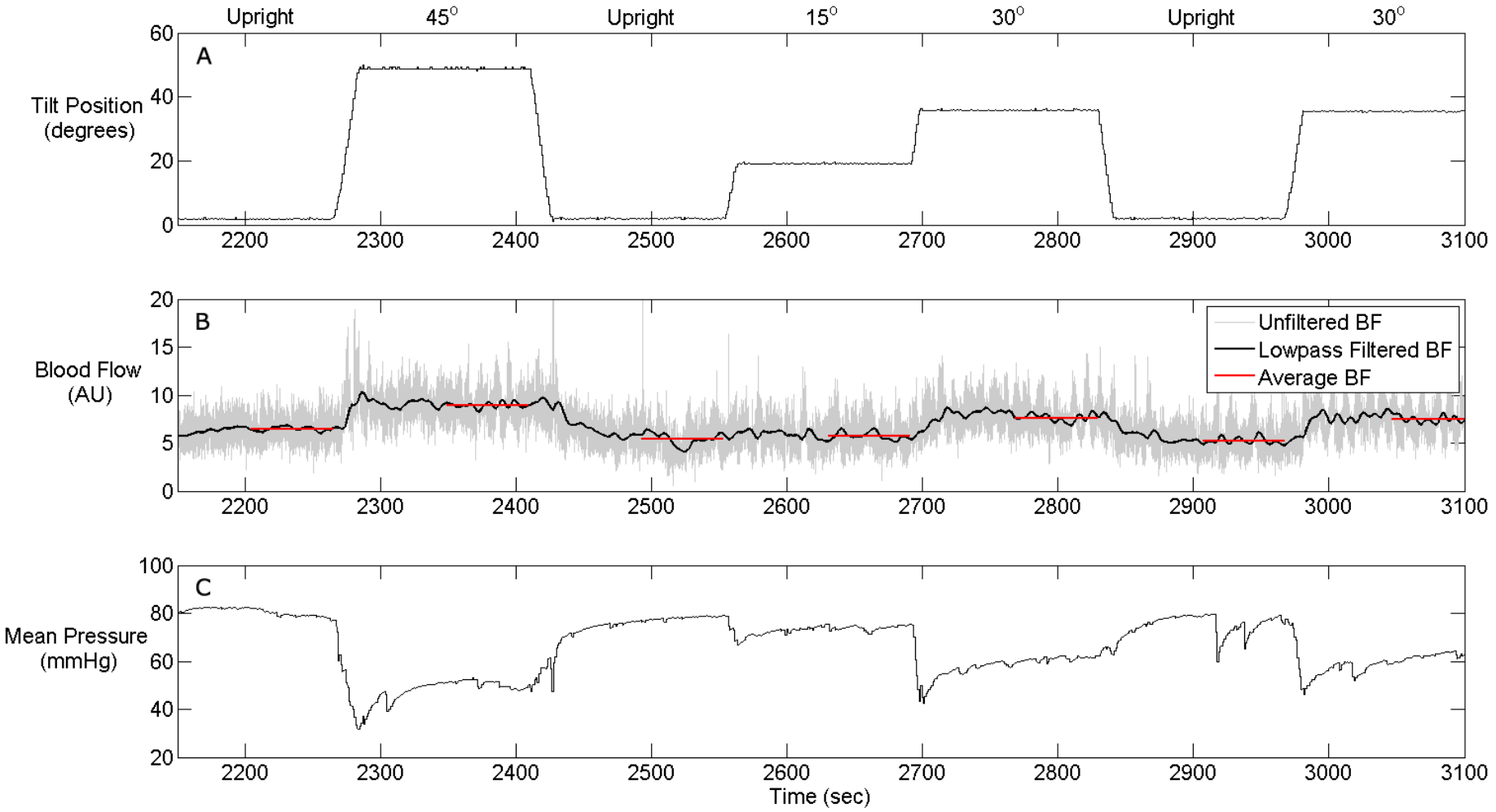
3 trials per subject

1. Unload for 5 minutes to restore baseline flow.
2. Tilt sequences - in random order

   2 minutes at each position.

Upright → 15 → 30
Upright → 30
Upright → 45
Upright → max tilt

Sample data from a single trial



Results: Normalized Blood Flow

Tilt Position	Mean Blood Flow	*P*-value
15°	1.08 (0.19)	*0.016*
30°	1.24 (0.48)	*0.003*
45°	1.84 (1.84)	*0.007*
Max Tilt	3.34 (5.09)	*0.034*

Normalized pressure and blood flow values (normalized by preceding upright values). Statistics were computed for normalized blood flow compared with a ratio of 1.

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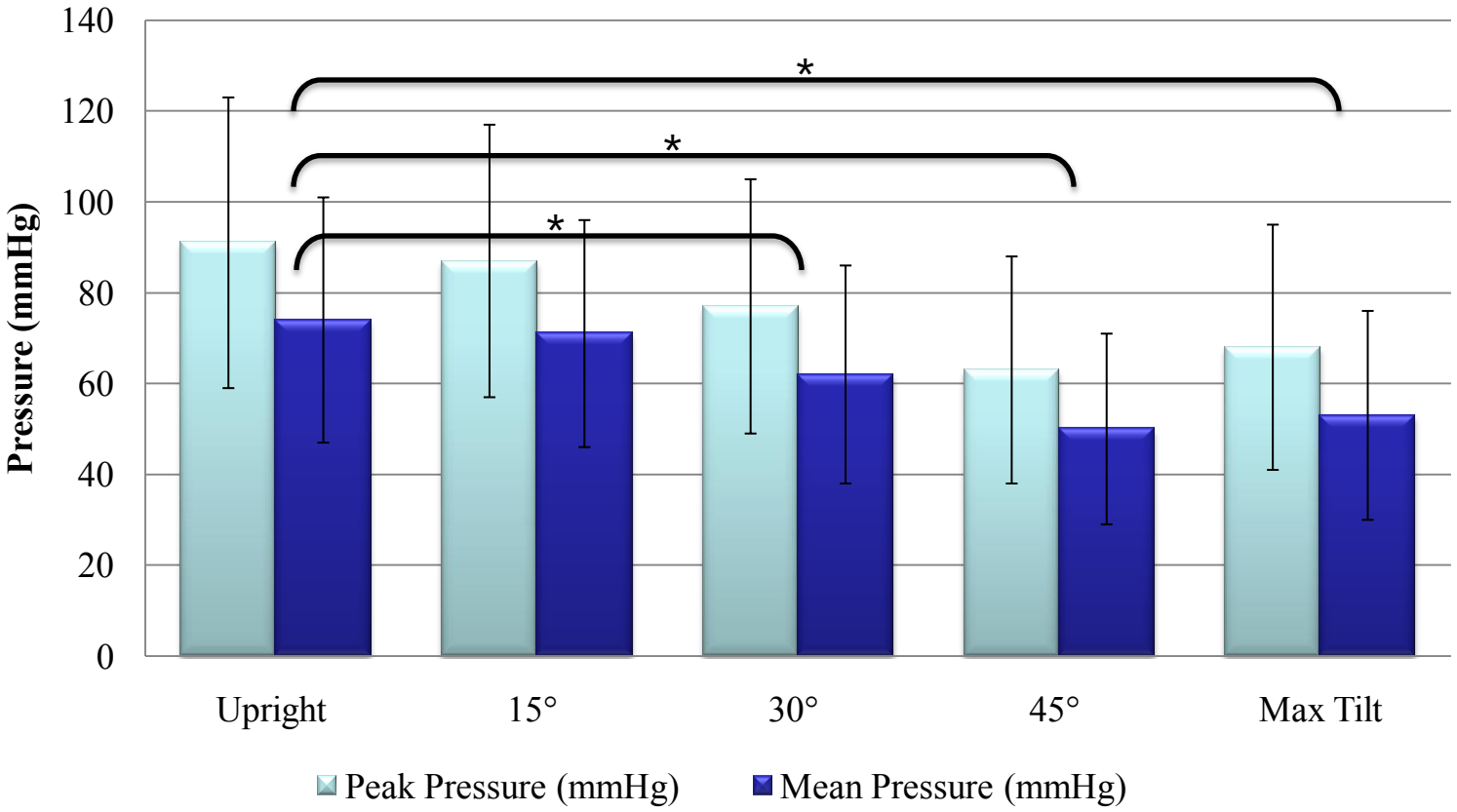
Results: Pressure



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  - ☑ – increased blood flow
  - x – decreased pressure.
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Results: Small Tilts from 15°

Variable	15°	30°	P-Value
Absolute Peak Pressure (mmHg)	87 (30)	75 (27)	< 0.001
Absolute Mean Pressure (mmHg)	71 (25)	61 (22)	< 0.001
Normalized Mean Blood Flow	1.08 (0.19)	1.15 (0.41)	0.118

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☒ – increased blood flow

☑ – decreased pressure.

Preliminary Pressure Relief Guidelines

- 9 of 11: increase in blood flow (≥ 10%) during the maximum tilt
- 4 of 11: increase in blood flow of ≥ 10% at 30° tilt

- Instruct users to tilt as far as the seating system permits for pressure relief.
- The use of interim small tilts is also supported, as they also provide some benefit.

How does this apply to actual tilt behavior?

- Monitored tilt behavior of 30 persons with SCI
- Pressure relieving tilts past 40° were rarely performed 0.1 times per hour of wheelchair occupancy

Actual Behavior

- Decreased loading (< 90% upright pressure)
  - Based on average pressure reduction, tilts > 24^{o} reduce pressure by 10%
  - Frequency: 0.5 (0.0 – 7.6) times per hour
  - Time: 7% (0% - 100%)

- Increased blood flow
  - Tilts > 15 ° increased blood flow
  - Frequency: 0.5 (0.0 – 7.0) times per hour
  - Time: 18% (0% - 100%)

Conclusions

- Tilting increases blood flow and decrease pressure
- Increase in blood flow NOT solely from pressure change
  - Change in CoP
  - Change in pelvic angle
  - Other factors such as Tissue Compression & Shear
- Considerable time spent with increased blood flow (18%) and decreased pressure (7%)
- Few pressure relieving tilts, infrequent changes to blood flow or pressure (every 2 hours)
- Possible explanations for not doing more PRTs
  - Large tilts may be uncomfortable and unstable
  - Large tilts may not be functional
  - Participants may not pay attention to the need for pressure reliefs

Limitations

- Generalization of results
  - Small n (11)
  - Limited cushions (Roho air inflation cushion)
  - Homogenous population
- Analyzed superficial blood flow only
- Hyperaemic responses were not studied, but may be important
- Short durations of loading
- Other contributors to pressure ulcers not studied:
  - Cell deformation
  - Shear
- Guidelines do not reflect efficacy at preventing pressure ulcers

Future Studies

- Longer sitting durations
- Measure deeper blood flow and oxygenation
- Vary wheelchair cushions
- More subjects
- Tissue deformation in MRI
- Measure shear forces
- Training interventions to influence tilt behavior
- Study pressure relief behavior and pressure / blood flow response other populations
- Efficacy of pressure reliefs in preventing pressure ulcers

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Questions?